GeoStabilization International®

The Varied Use of Compaction Grouting for Roadway Rehabilitation

Purdue Road School
March 2016

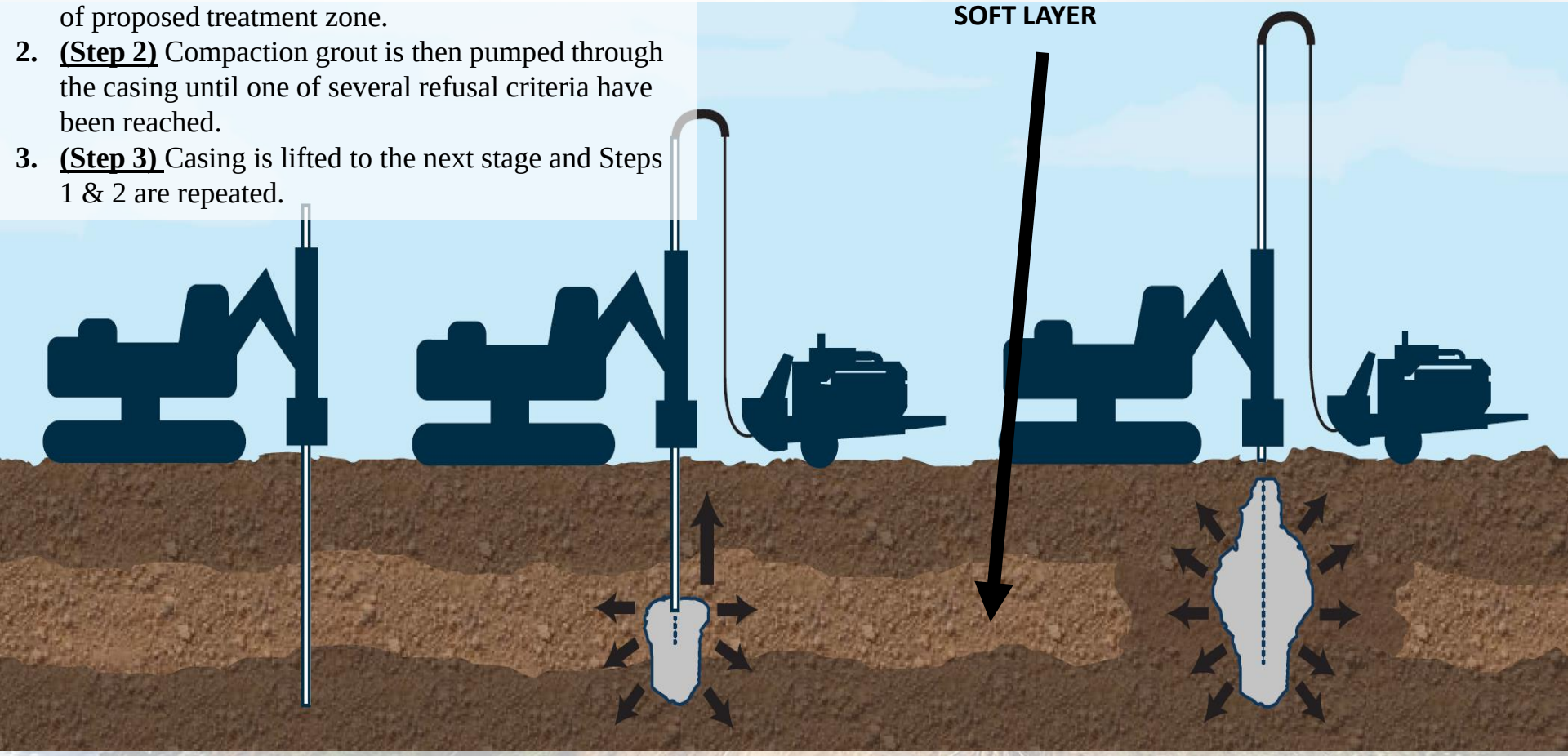
Tom Szynakiewicz, P.E., D.GE

Compaction Grouting

Compaction grouting, otherwise known as Low Mobility Grouting (LMG) is the injection of low slump (typically less than 1”) cementitious grout into weak or soft soil layers throughout a weak soil profile in a primary/secondary pattern in order to **densify the soils for the purpose of increasing bearing capacity, decreasing settlement potential or general improvement**

Compaction Grouting

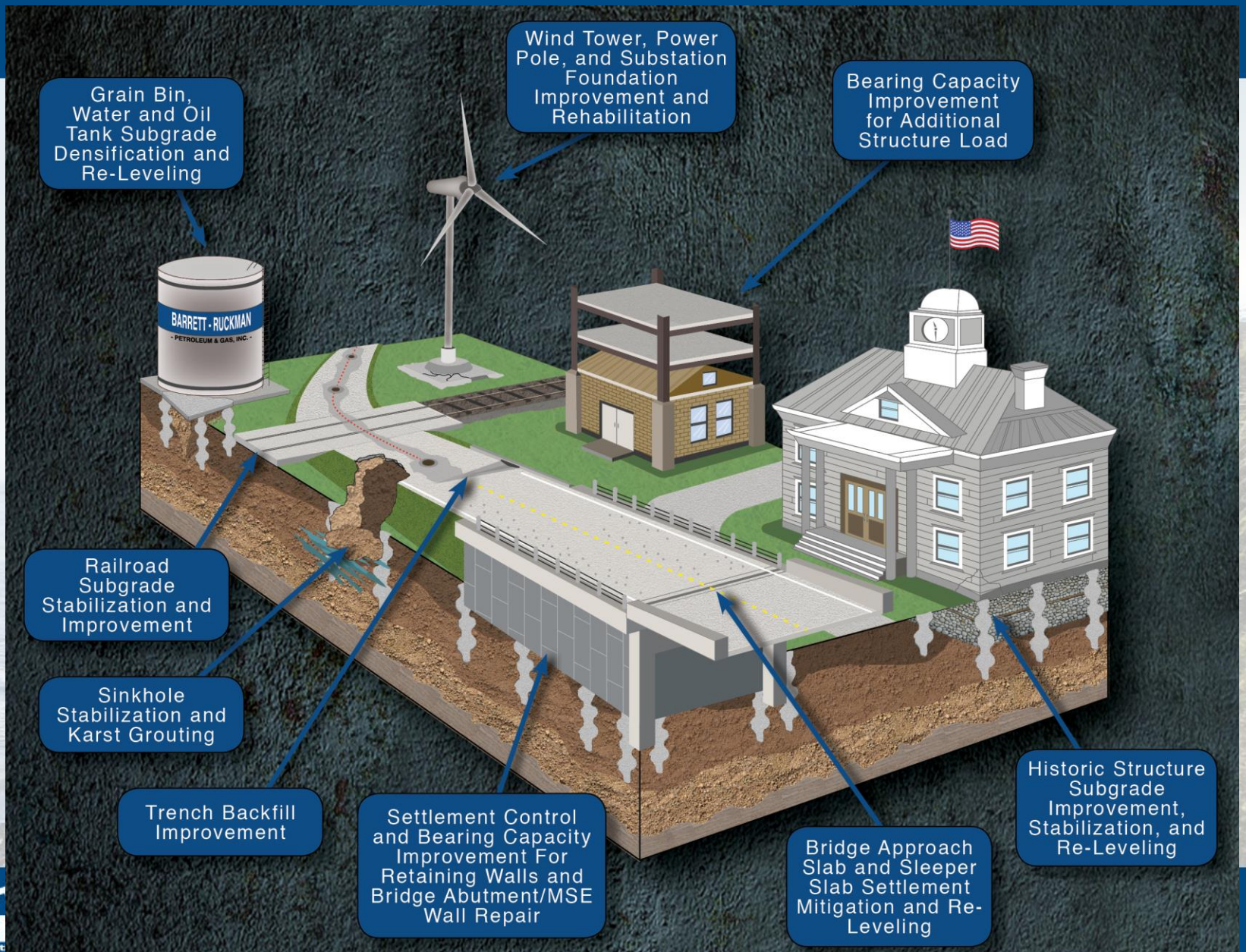
1. **(Step 1)** Hole is drilled or casing is driven to bottom of proposed treatment zone.
2. **(Step 2)** Compaction grout is then pumped through the casing until one of several refusal criteria have been reached.
3. **(Step 3)** Casing is lifted to the next stage and Steps 1 & 2 are repeated.



Advantages of Compaction Grouting

- Precise treatment
- Fast installation
- Can be performed in very tight access and low headroom
- No waste spoil disposal
- Wide applications range
- Non-destructive and adaptable to existing foundations
- Cost effective alternative to removal and replacement or piling
- Time tested and proven
- Site batching allows for necessary adjustments on the fly to maximize results

Geotechnical Compaction Grouting Applications



Ideal Grout Make-Up

- Aggregate:
  - 100 % passing 3/8”
  - 15-25% passing #200
  - Rounded pea gravel helps
- 10-20% cement by volume
- Slump is very important – typically less than 2” for pre-treatment and around 1” for underpinning and piles

Compaction Grouting QA/QC

- Grout logs for every hole at every one ft stage during production
- Pre-production test program can evaluate improvement
- Pre and Post SPT's
- CPT's
- Primary/Secondary nature of the method "notices" improvement between primary and secondary holes
  - Higher pressures
  - Lower grout takes

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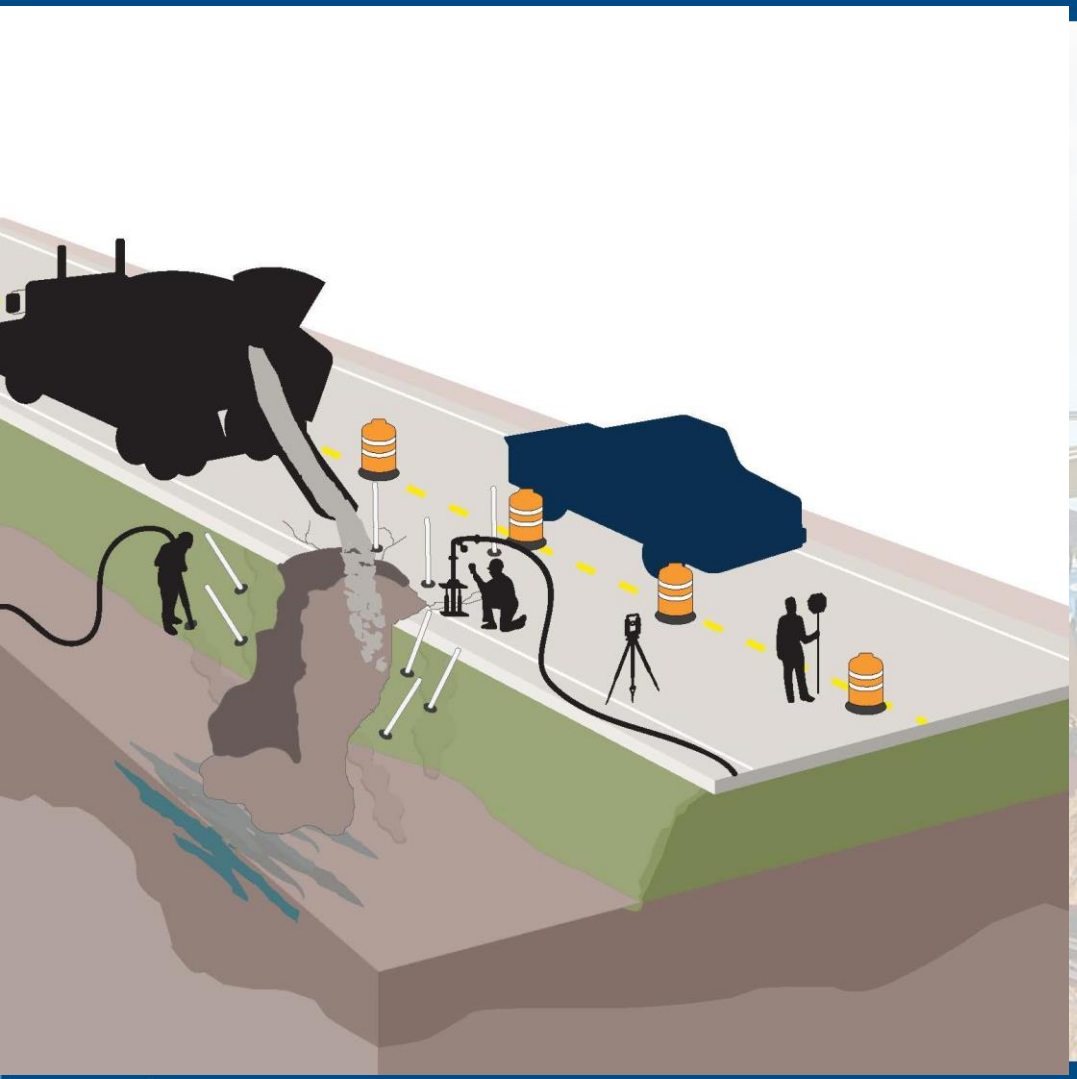
Day-to-Day Compaction Grouting Applications

Sinkholes

Karst Related
(nature caused)

Culvert/Tunnel/Utility Collapse
(man caused)

Sinkholes



Emergency Sinkhole Stabilization and Repair Typically Consists of Two Components:

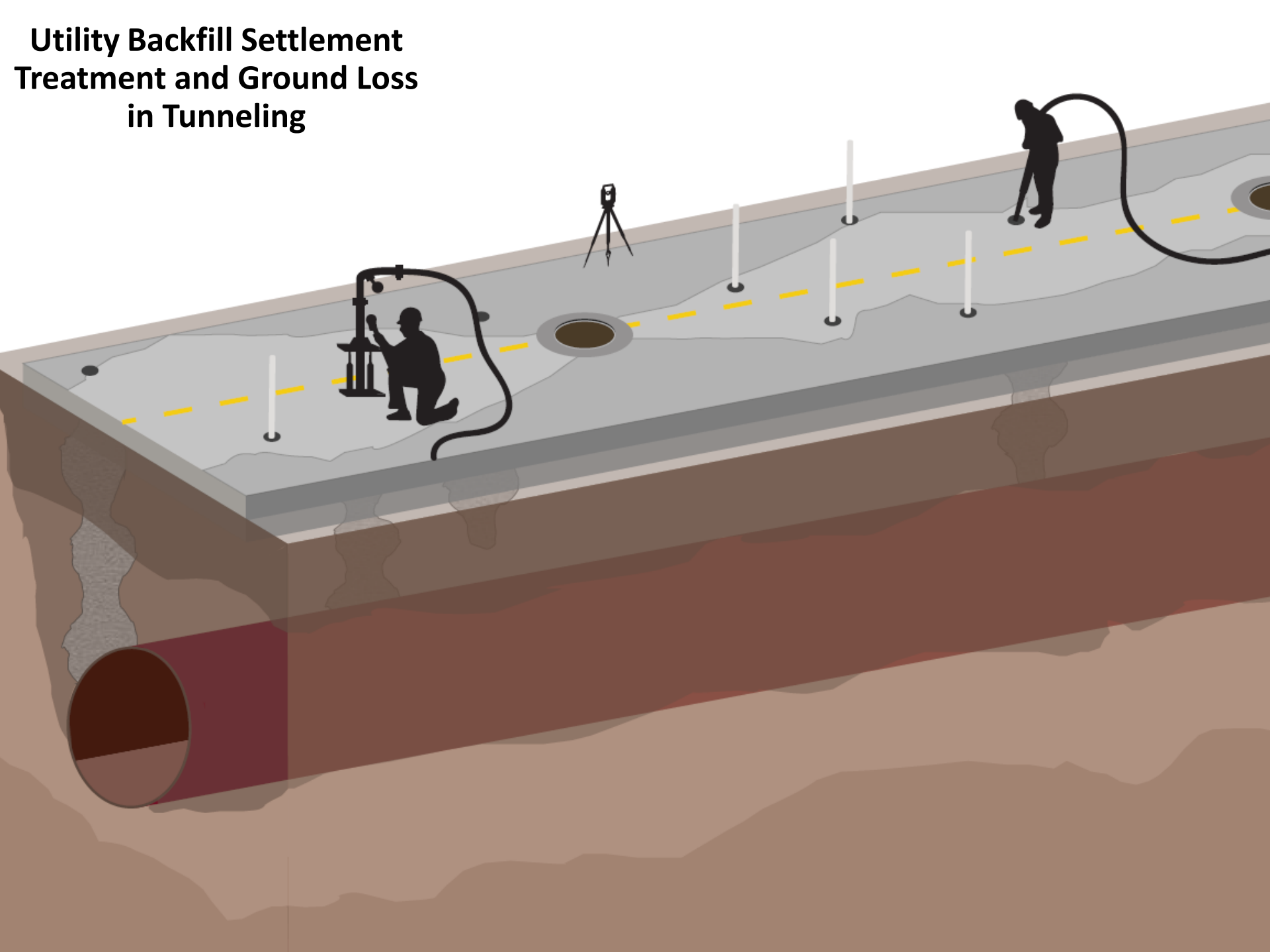
- Backfilling the sinkhole from surface with a flowable fill material often from a ready-mix plant, or material produced with on-site batchers
- Deep compaction grouting into the throat of the sinkhole in order to choke it off so that the flow fill can begin to fill it up
- Once the sinkhole is stabilized, a pattern of compaction grouting can be performed around the sinkhole in overburden soils in order to find and densify and loosened soils and or voids that may not have yet collapsed or propagated to the surface

Collapsing Mine Shafts

Roadway Embankment Stabilization

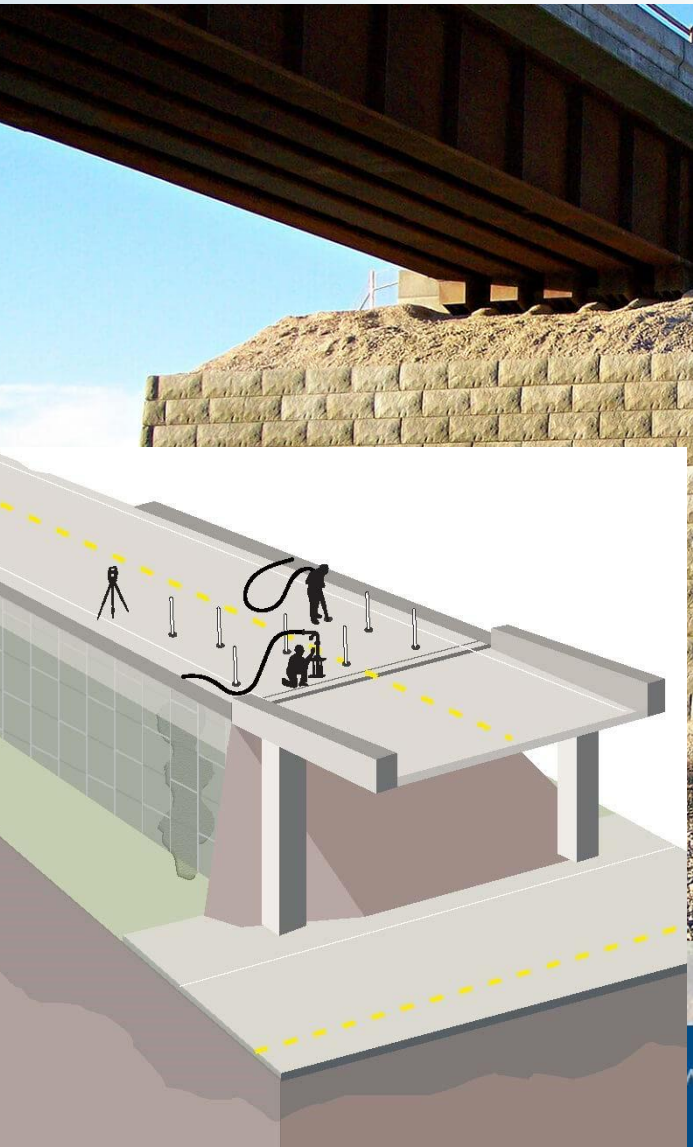
Soft soils on fill side of roadway settle over time

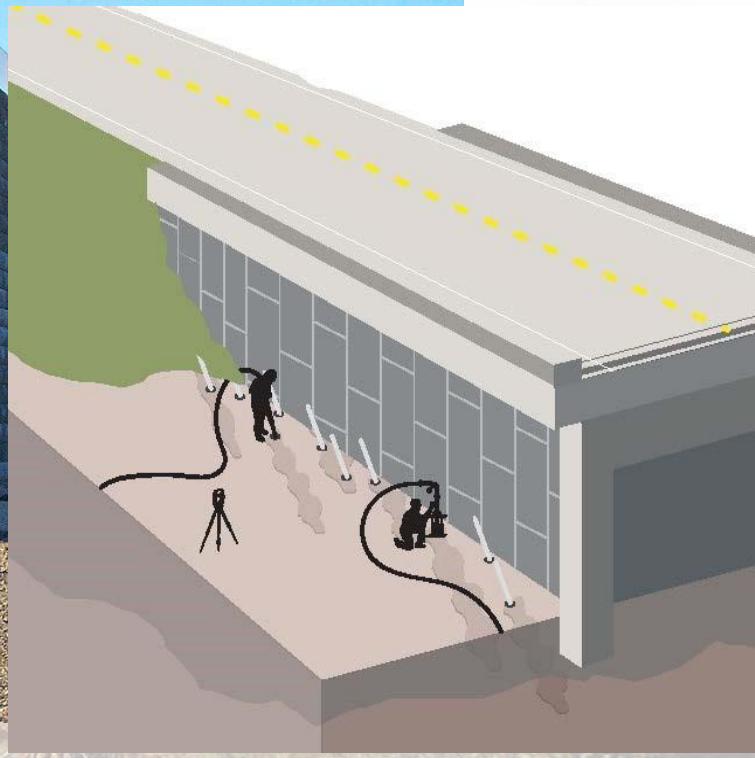
Utility Backfill Settlement Treatment and Ground Loss in Tunneling



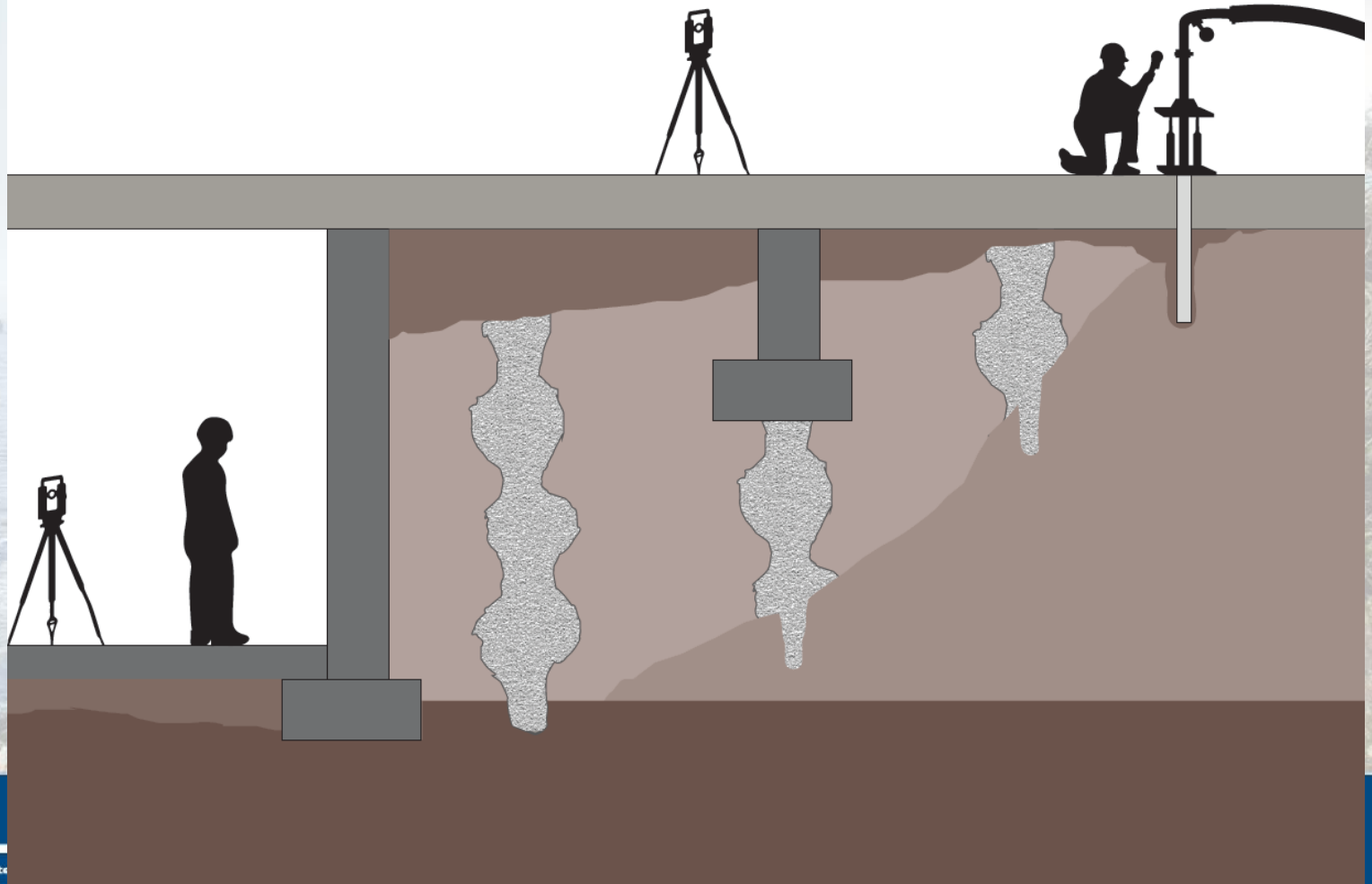
Night Work on Roadways Allows Road Reopening During Day

Settlement Reduction From Fill Loads

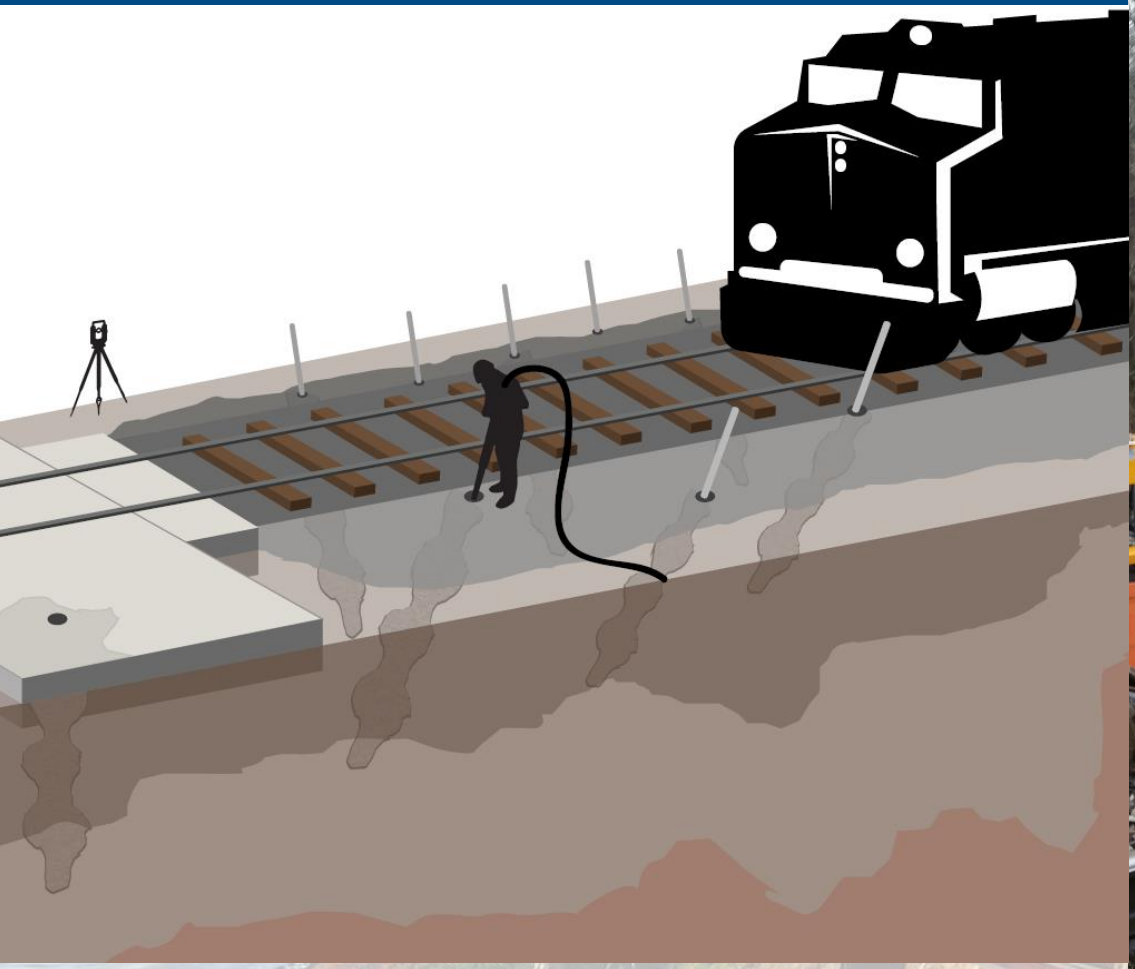


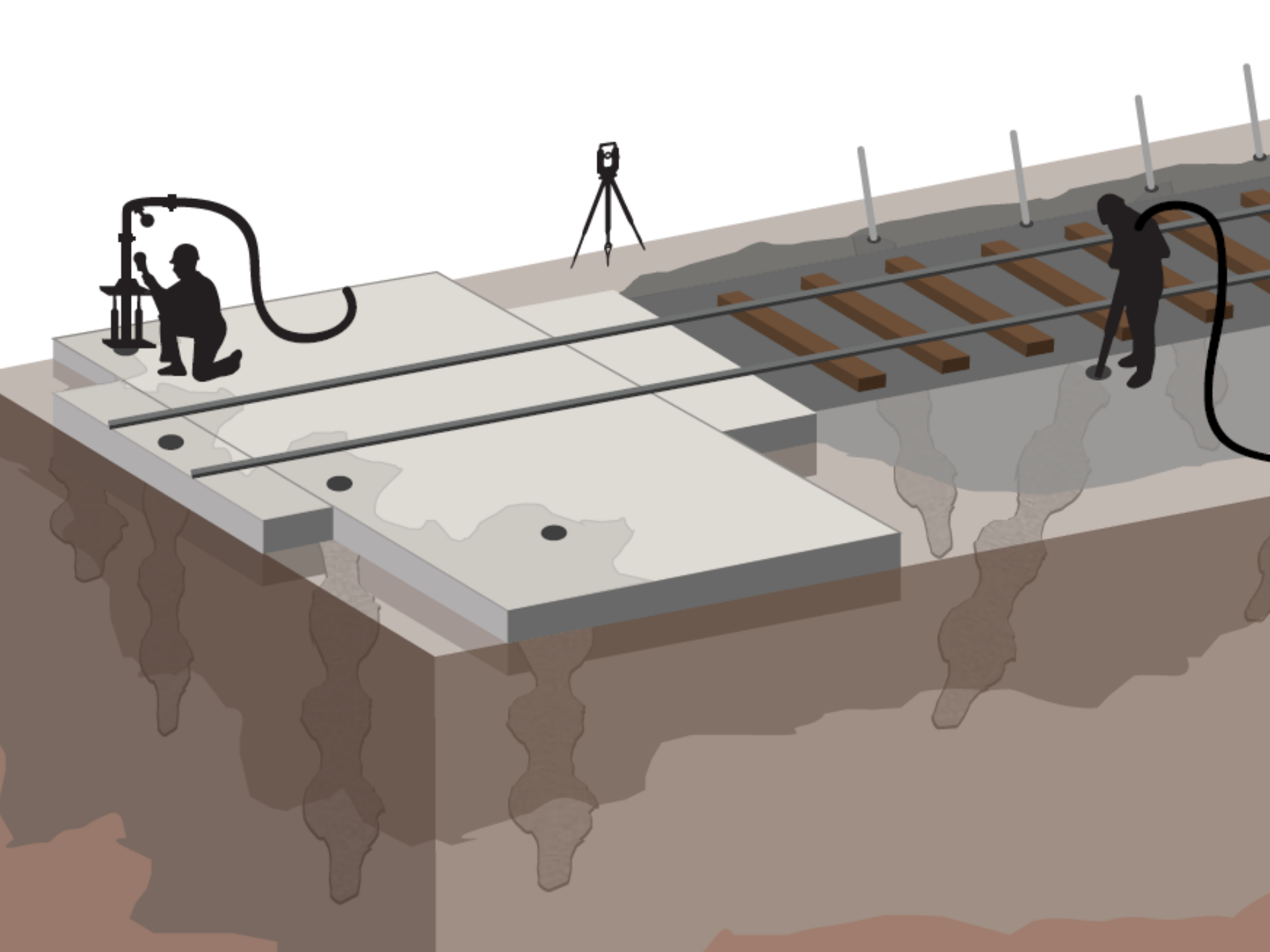


Abutment and Fill Settlement Reduction



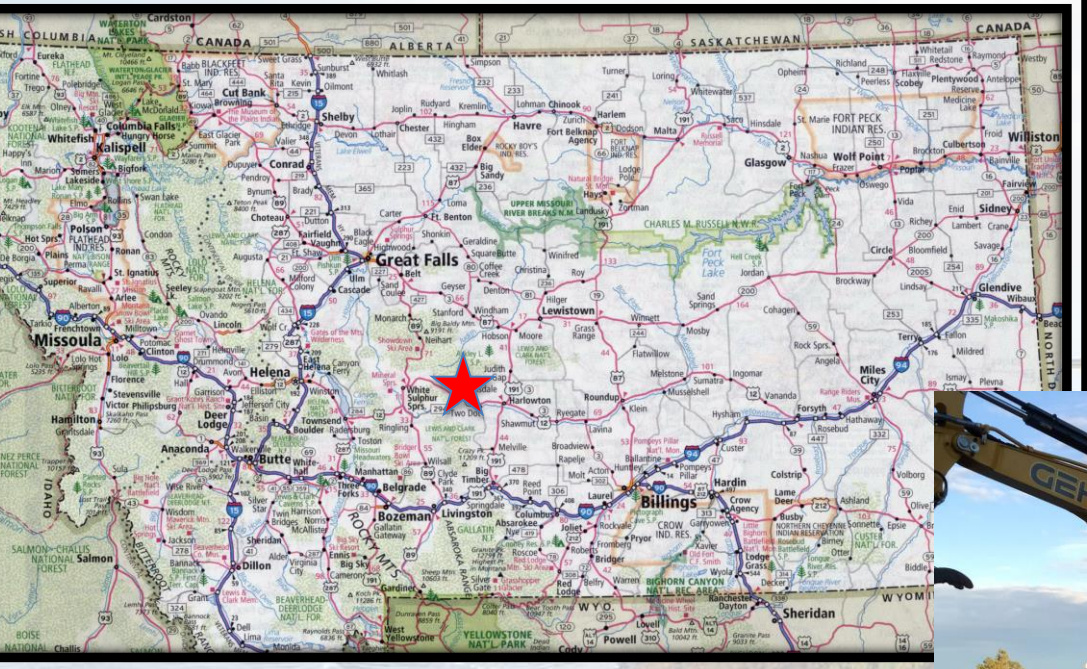
RR Subgrade Treatment



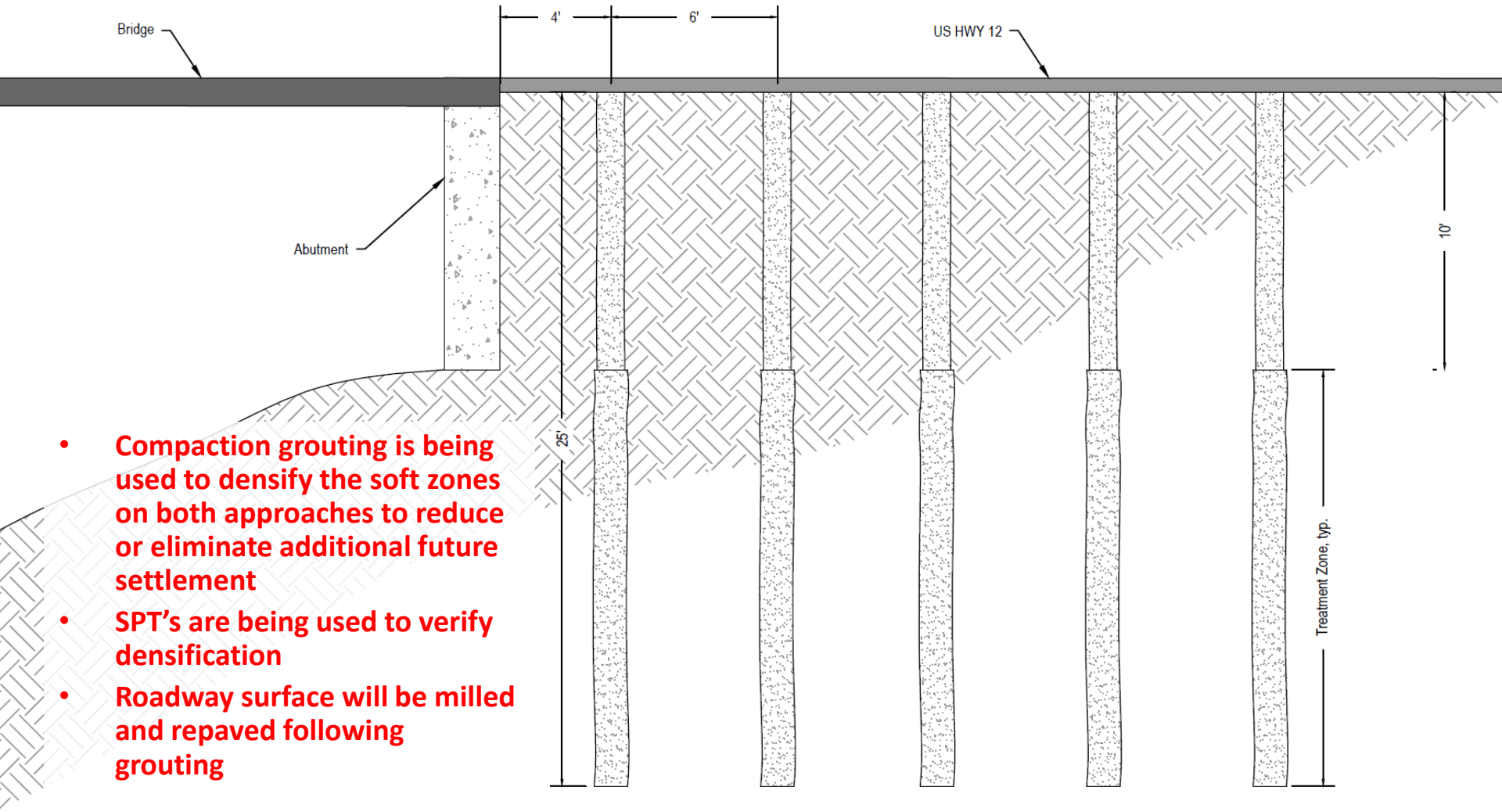


US HWY 12- Cooper Creek Bridge Approach Settlement Mitigation

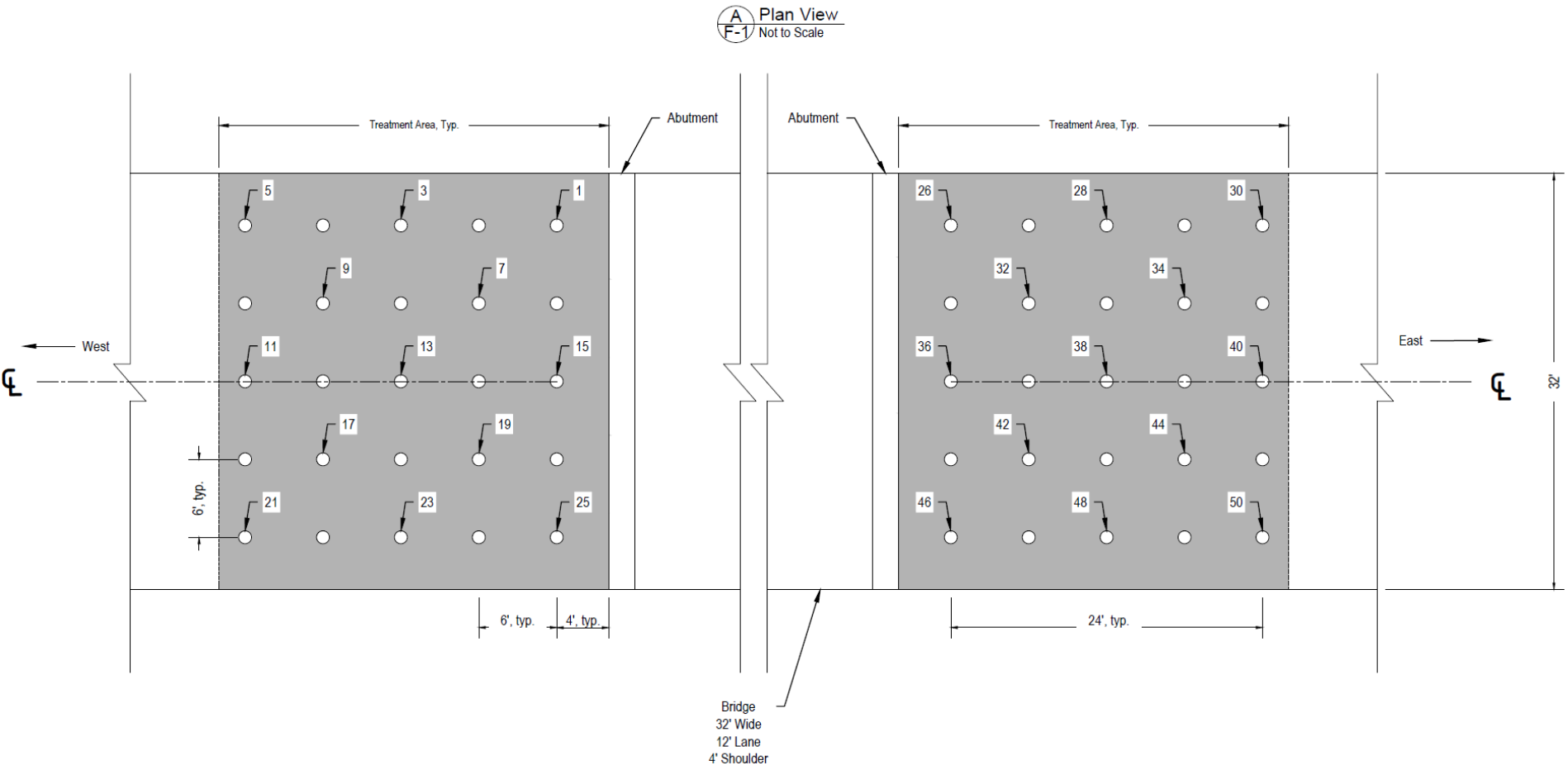
White Sulphur Springs, MT



- Bridge was replaced several years ago
- Approaches started settling immediately afterwards
- Approaches were repaved several times
- Subsequent borings showed loose abutment fill from 10 – 25 ft bgs



- Compaction grouting is being used to densify the soft zones on both approaches to reduce or eliminate additional future settlement
- SPT's are being used to verify densification
- Roadway surface will be milled and repaved following grouting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Treatment Area, Typ.
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24', typ.
32'
Bridge
32' Wide
12' Lane
4' Shoulder

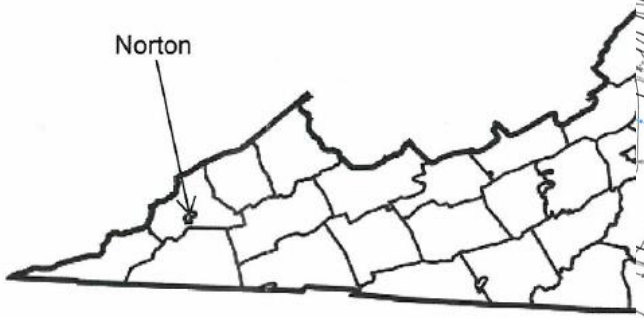

10167282
GEHL

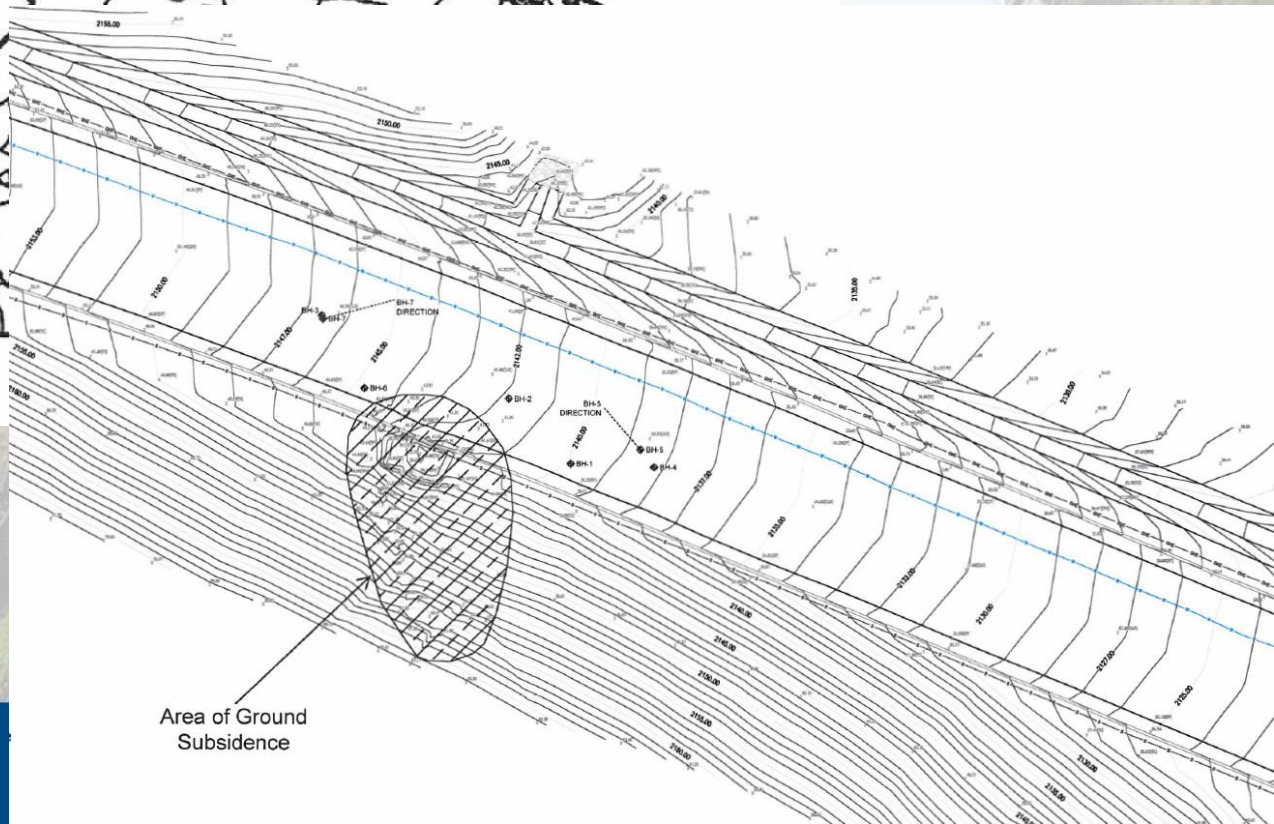

Portamesher

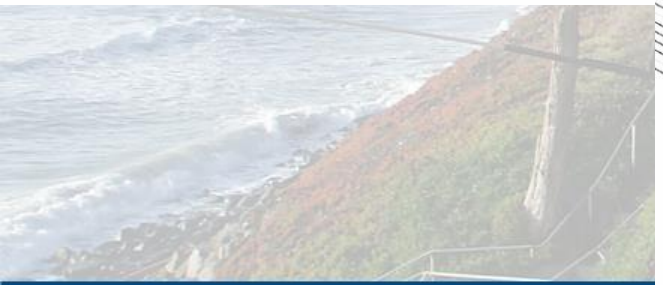

Power Team
SPX

Coal Mine Collpase Mitigation

Norton, VA







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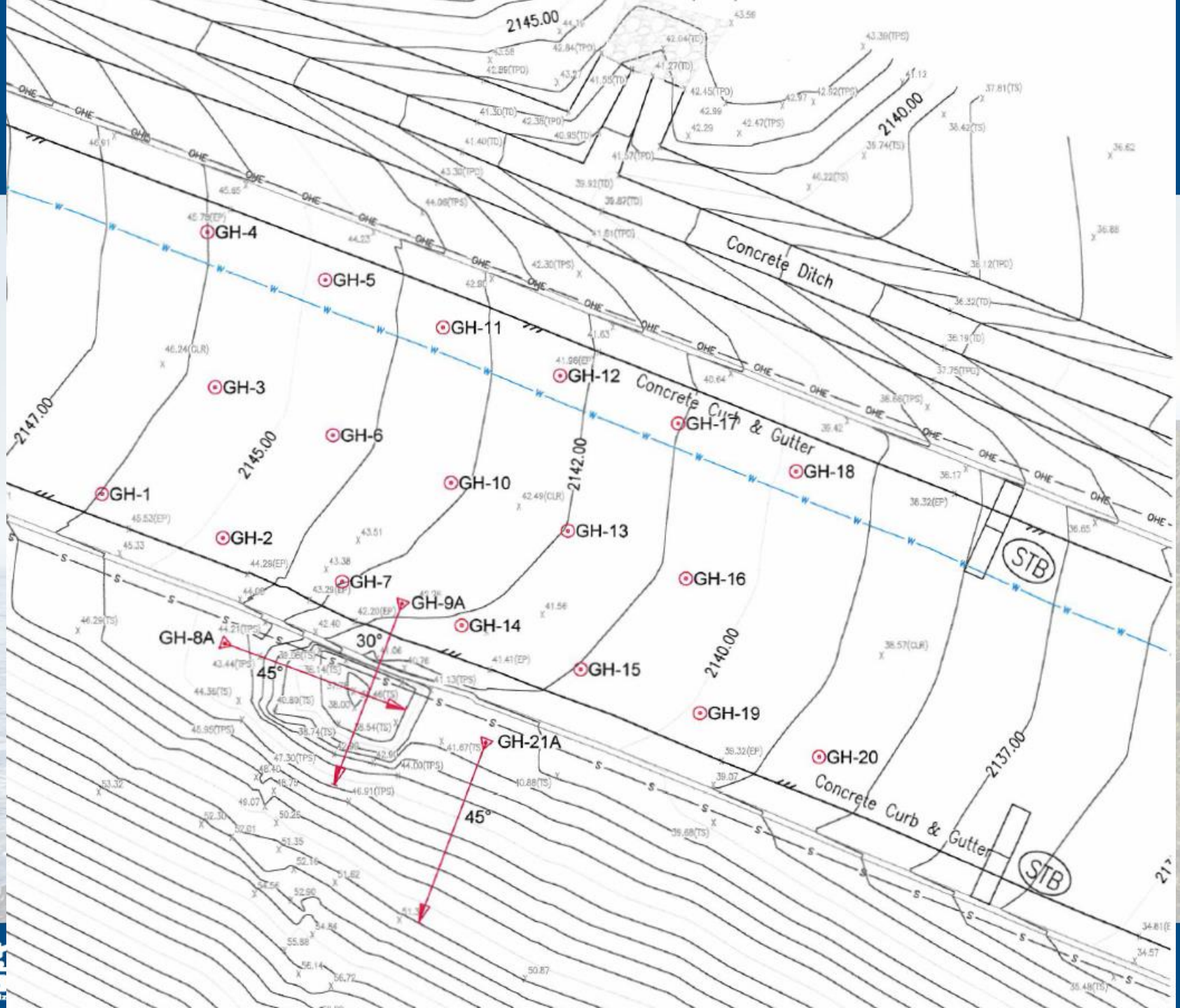
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45°
Concrete Ditch
Concrete Curb & Gutter
Concrete Curb & Gutter
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STB
OHE
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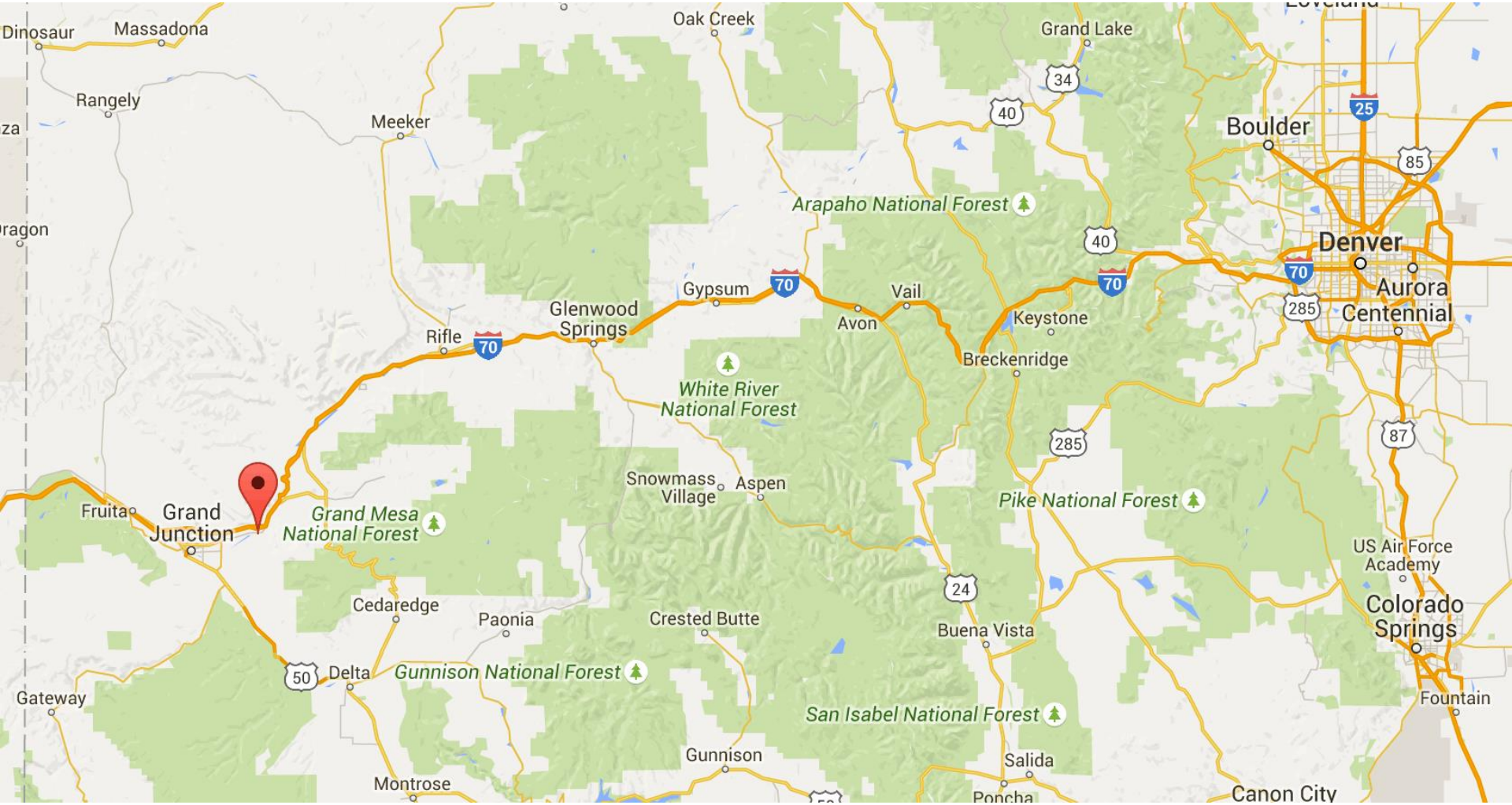
GSI
GeoStabilization International®

38 Road Improvements MSE Wall Repair



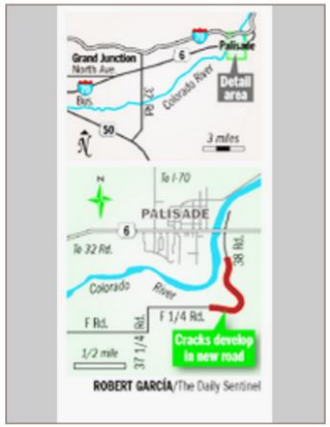
38 Road Improvements MSE Wall Repair


Rio Vista Mobile Home Park
Brentwood Ln
River Forest Manufactured Home Park
Colorado River
38 Rd
Orchard Mesa Irrigation District
Colorado River
39 Rd
Orchard Mesa Canal Number 1
Orchard Mesa Canal Number 2
Colorado River
39 Rd
Talbott Farms
Aldee Vista Ct
38 Rd

40° F
Mostly Cloudy
Wind SE at 3 MPH
Pressure 1012 MB
Dewpoint 30° F
Visibility 10 miles
Area forecast >

THE DAILY SENTINEL
GRAND JUNCTION, COLORADO

Fissures appear in asphalt on freshly overhauled 38 Road



By Mike Wiggins
Friday, August 21, 2015

When government officials and farmers gathered last week to celebrate the reconstruction of the 38 Road hill connecting Palisade and East Orchard Mesa, they hailed the $2.1 million project as a significant improvement in safety for motorists and bicyclists alike.

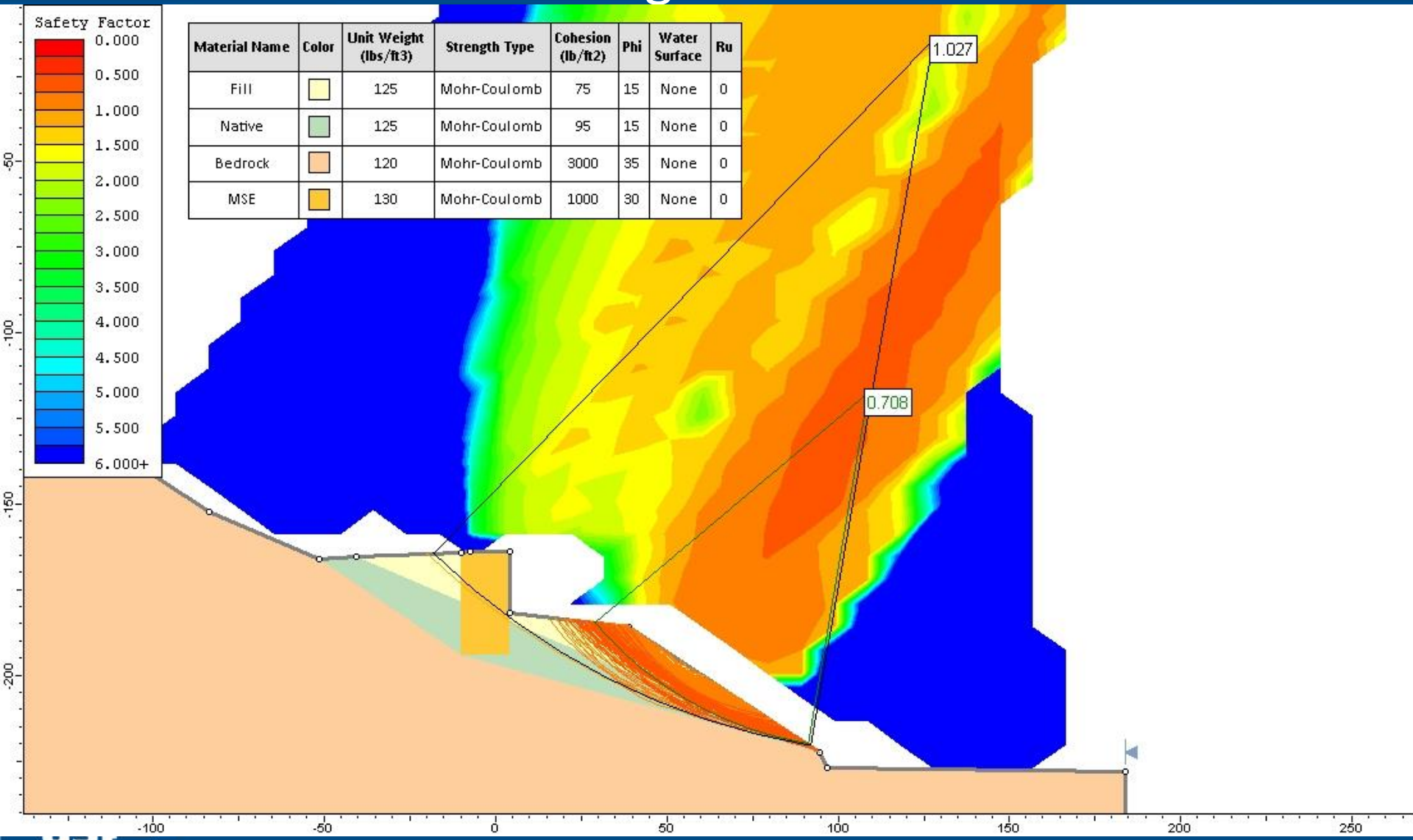
But a little farther up the road, out of the view of the ceremonial ribbon-cutting, the hill had already begun moving, opening up several large cracks in the fresh asphalt.

Mesa County engineers and the general contractor on the project have now brought in a geohazard mitigation company to stabilize a retaining wall that began failing — and taking the road with it — even before dignitaries shook hands and posed


MSE Wall Rotated Outward and Settled Immediately After Completion of Construction

First Stability Model Iteration

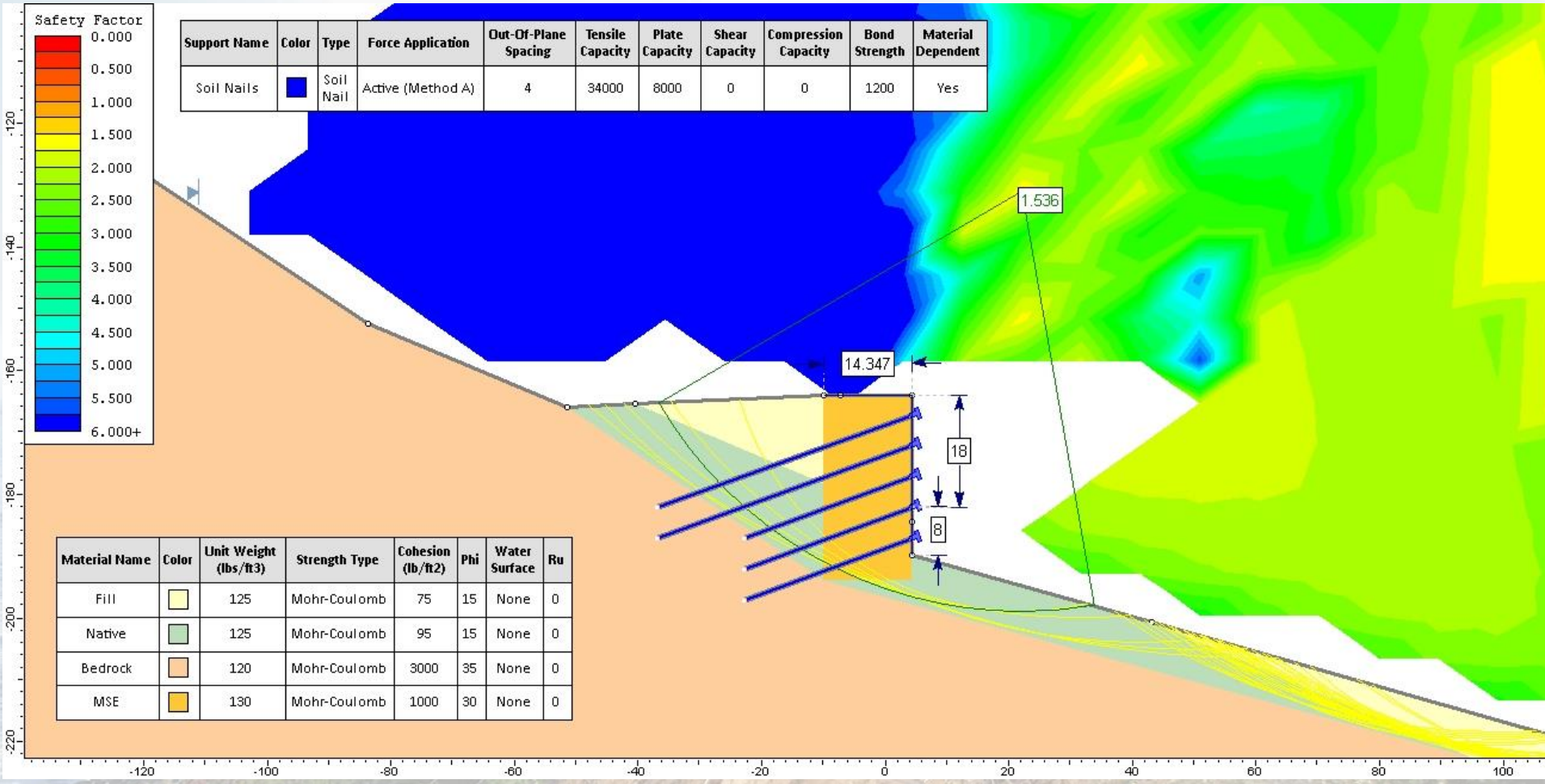
Existing Condition



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (lb/ft2)	Phi	Water Surface	Ru
Fill		125	Mohr-Coulomb	75	15	None	0
Native		125	Mohr-Coulomb	95	15	None	0
Bedrock		120	Mohr-Coulomb	3000	35	None	0
MSE		130	Mohr-Coulomb	1000	30	None	0

First Stability Model Iteration

Repair Concept

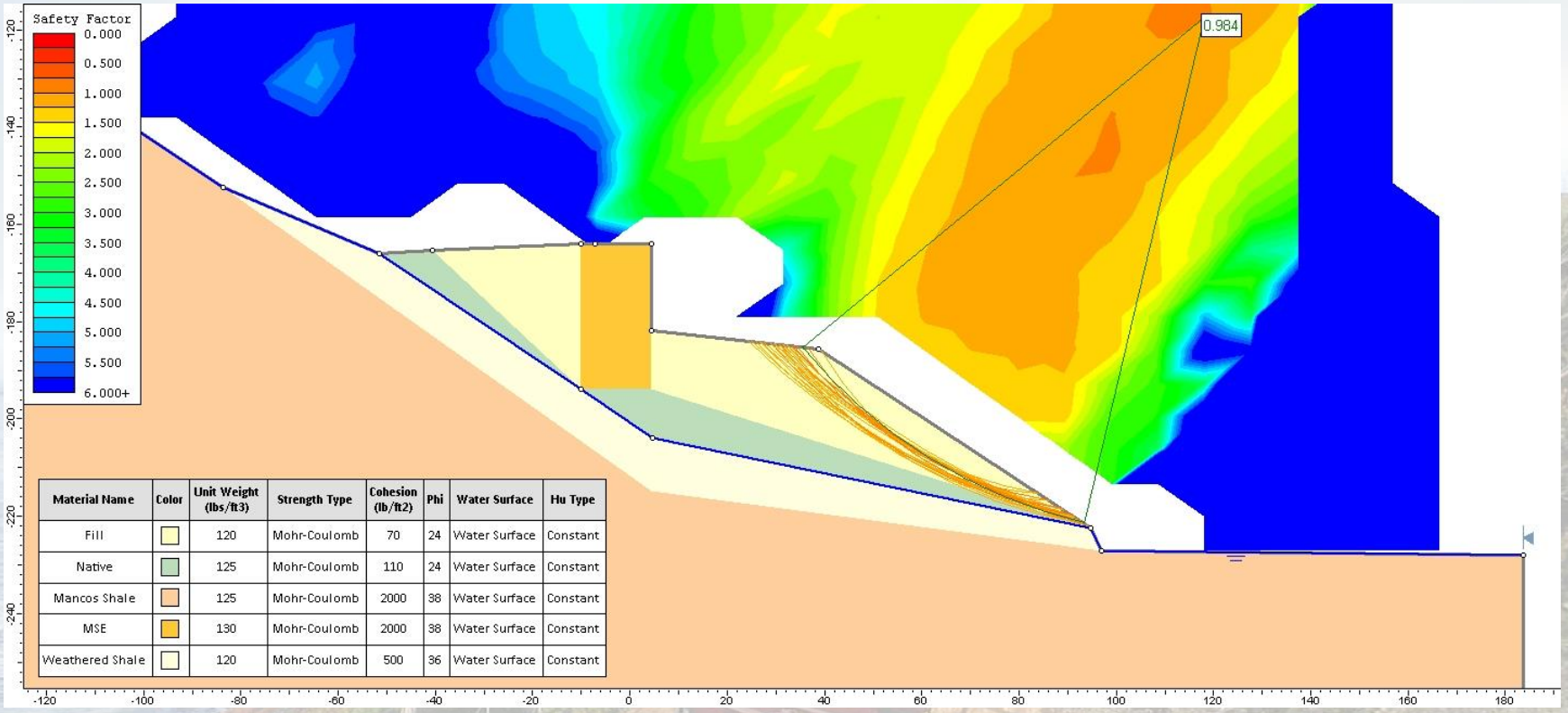


Support Name	Color	Type	Force Application	Out-Of-Plane Spacing	Tensile Capacity	Plate Capacity	Shear Capacity	Compression Capacity	Bond Strength	Material Dependent
Soil Nails		Soil Nail	Active (Method A)	4	34000	8000	0	0	1200	Yes

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (lb/ft2)	Phi	Water Surface	Ru
Fill		125	Mohr-Coulomb	75	15	None	0
Native		125	Mohr-Coulomb	95	15	None	0
Bedrock		120	Mohr-Coulomb	3000	35	None	0
MSE		130	Mohr-Coulomb	1000	30	None	0

Second Stability Model Iteration

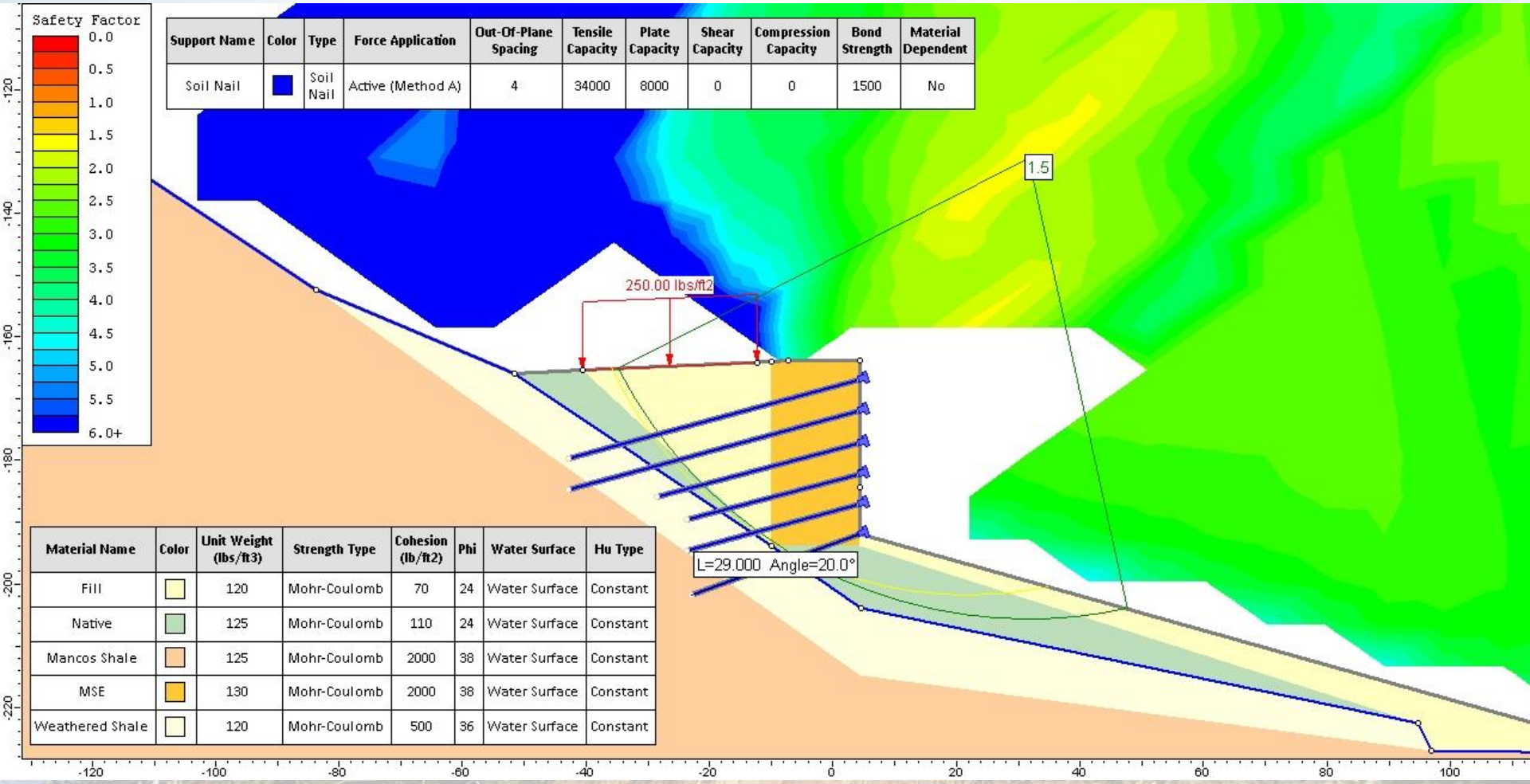
Actual Conditions



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (lb/ft2)	Phi	Water Surface	Hu Type
Fill		120	Mohr-Coulomb	70	24	Water Surface	Constant
Native		125	Mohr-Coulomb	110	24	Water Surface	Constant
Mancos Shale		125	Mohr-Coulomb	2000	38	Water Surface	Constant
MSE		130	Mohr-Coulomb	2000	38	Water Surface	Constant
Weathered Shale		120	Mohr-Coulomb	500	36	Water Surface	Constant

Second Stability Model Iteration

Repair Concept Following Site Evaluation



Support Name	Color	Type	Force Application	Out-Of-Plane Spacing	Tensile Capacity	Plate Capacity	Shear Capacity	Compression Capacity	Bond Strength	Material Dependent
Soil Nail		Soil Nail	Active (Method A)	4	34000	8000	0	0	1500	No

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (lb/ft2)	Phi	Water Surface	Hu Type
Fill		120	Mohr-Coulomb	70	24	Water Surface	Constant
Native		125	Mohr-Coulomb	110	24	Water Surface	Constant
Mancos Shale		125	Mohr-Coulomb	2000	38	Water Surface	Constant
MSE		130	Mohr-Coulomb	2000	38	Water Surface	Constant
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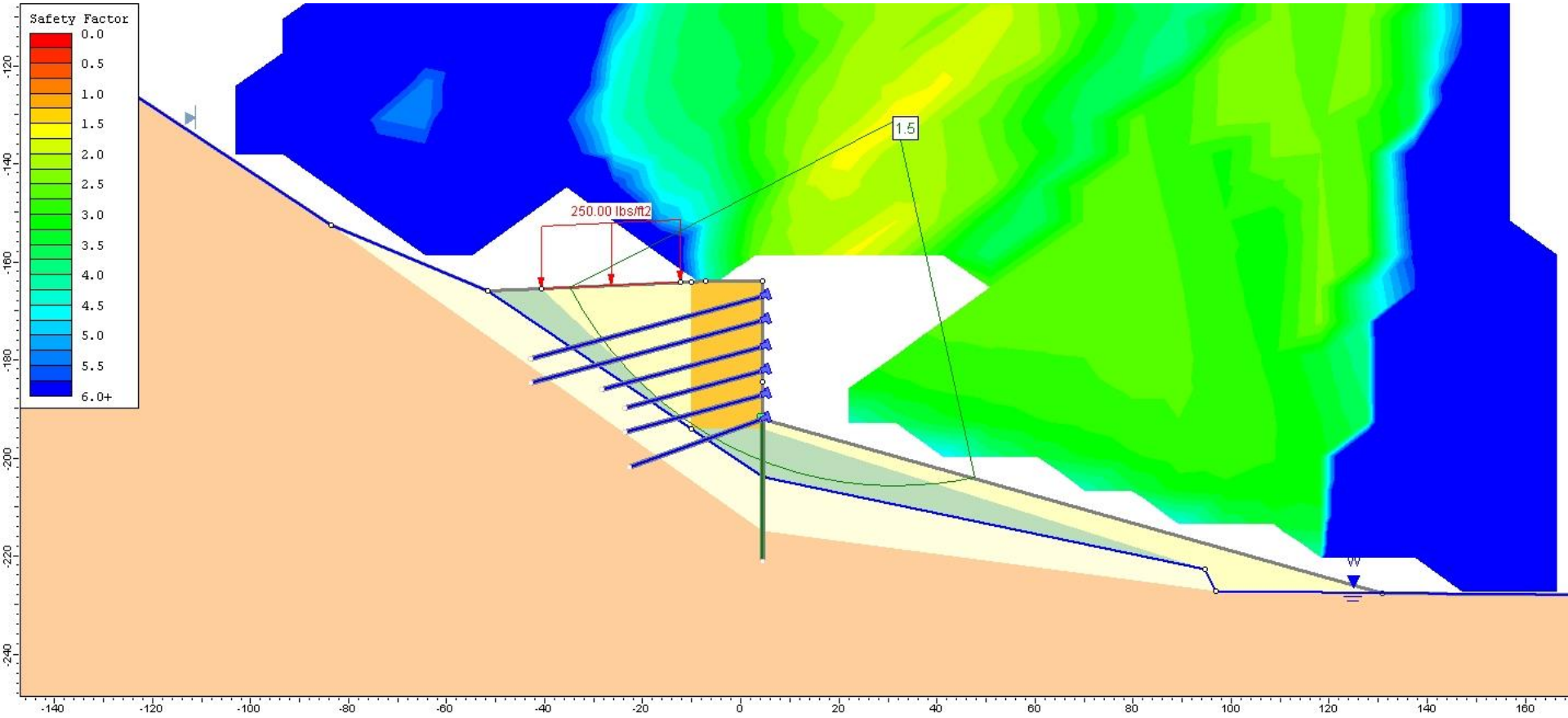
Safety Factor
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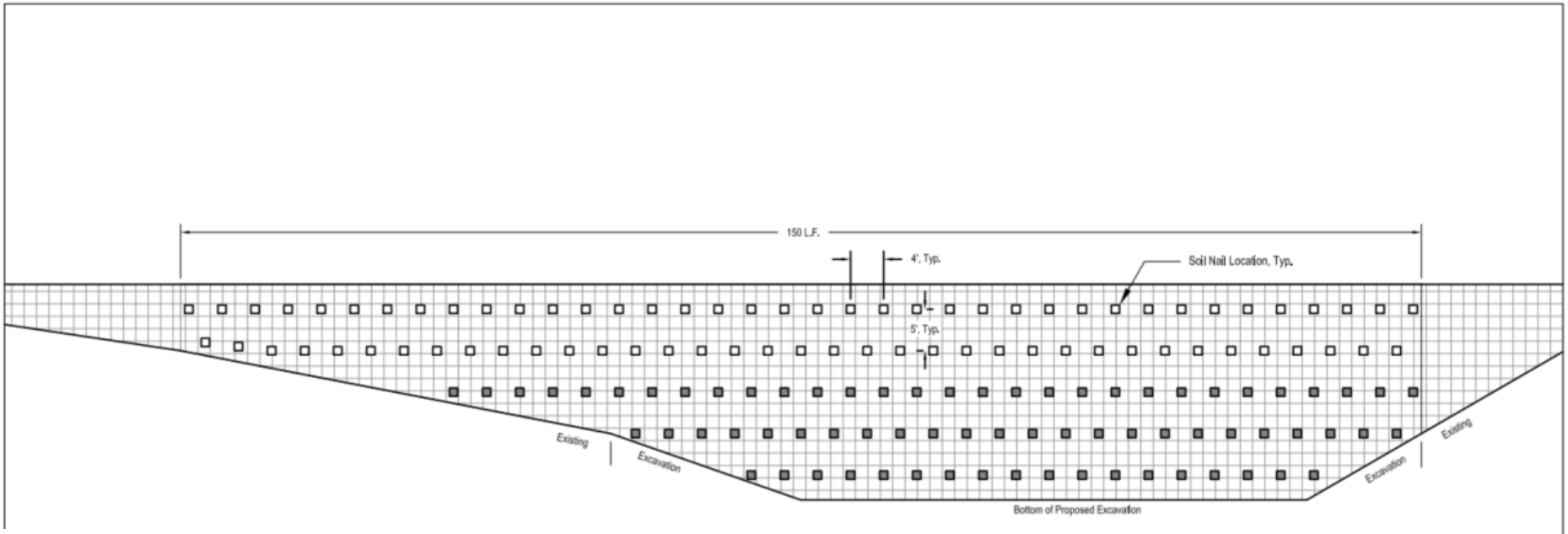

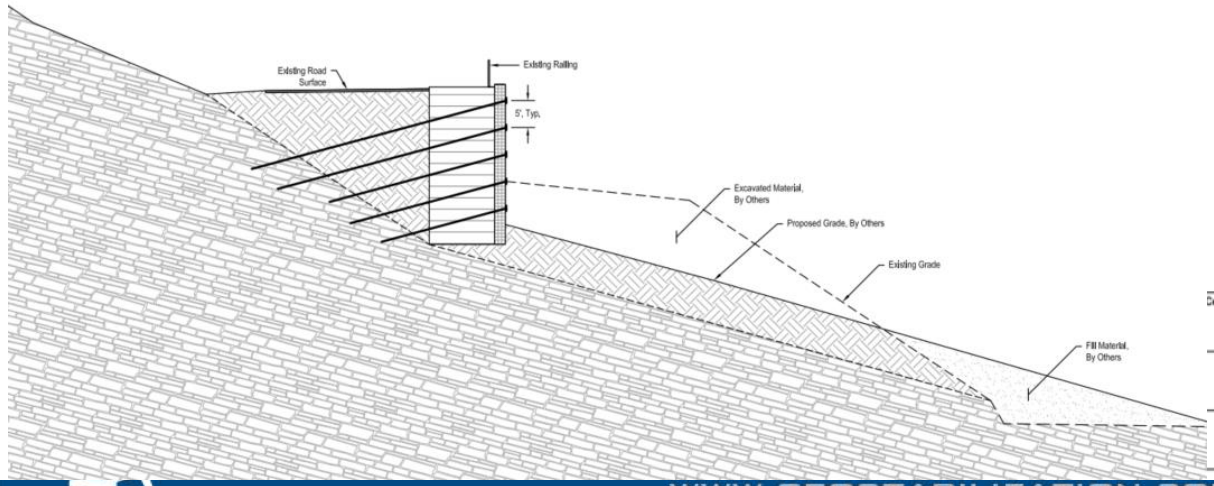

Code:

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GSI
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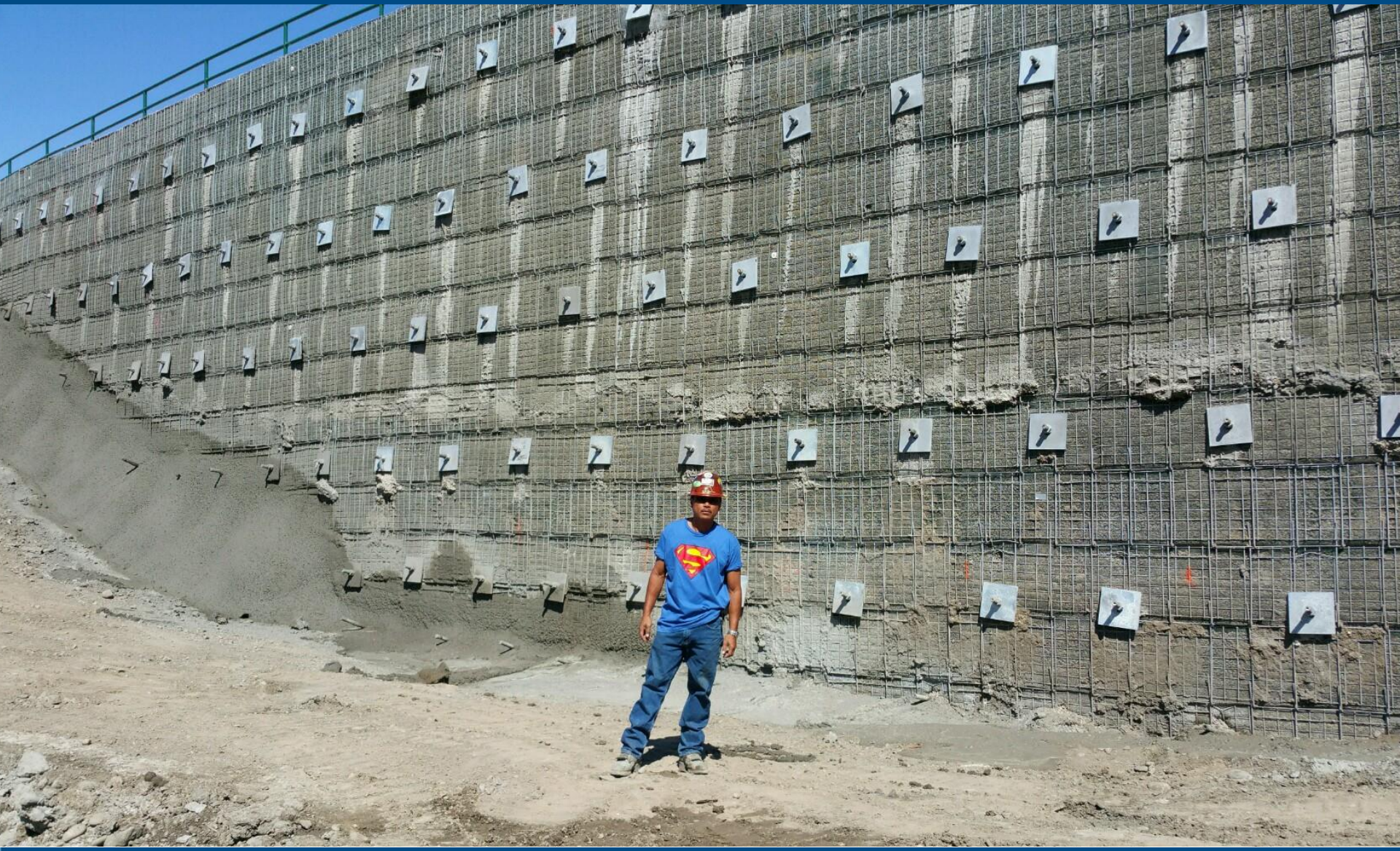

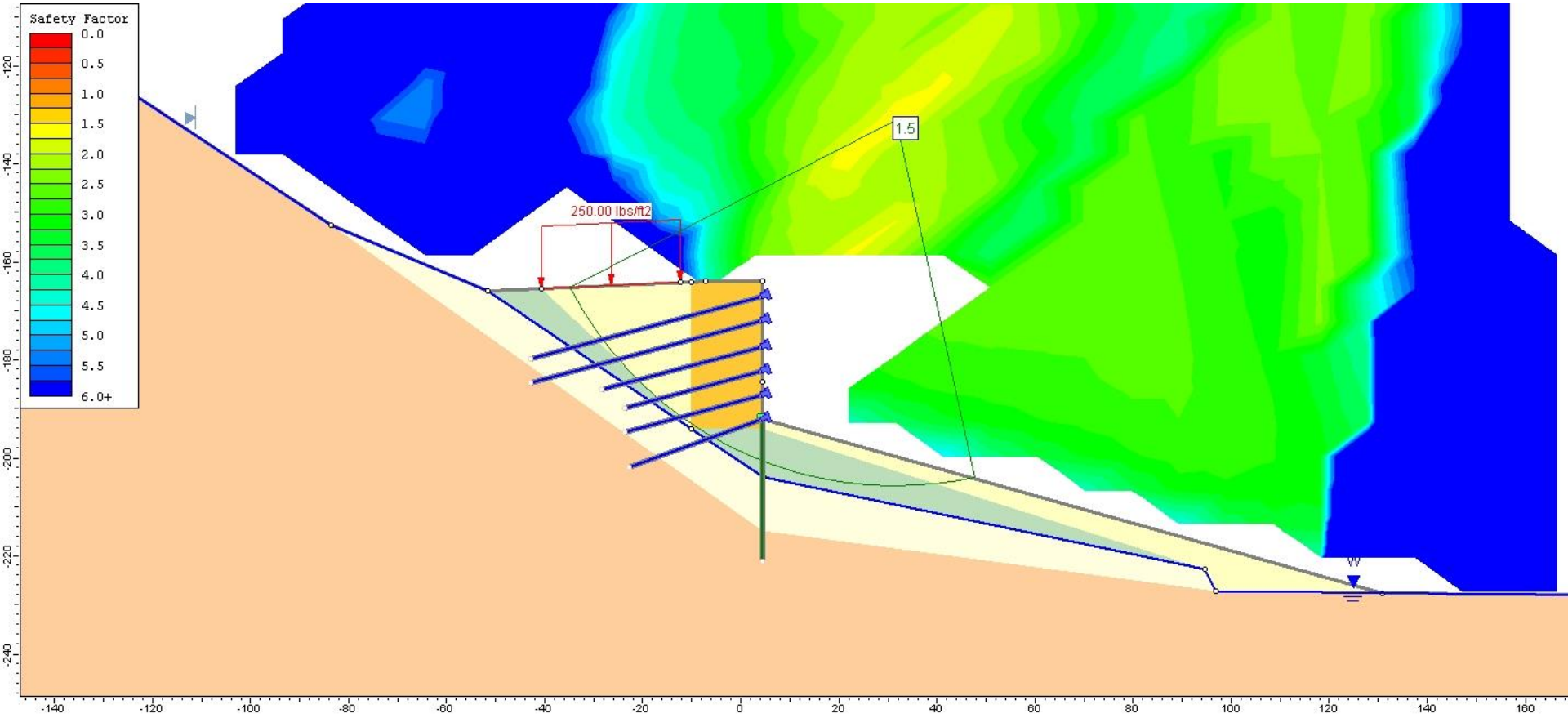
Safety Factor
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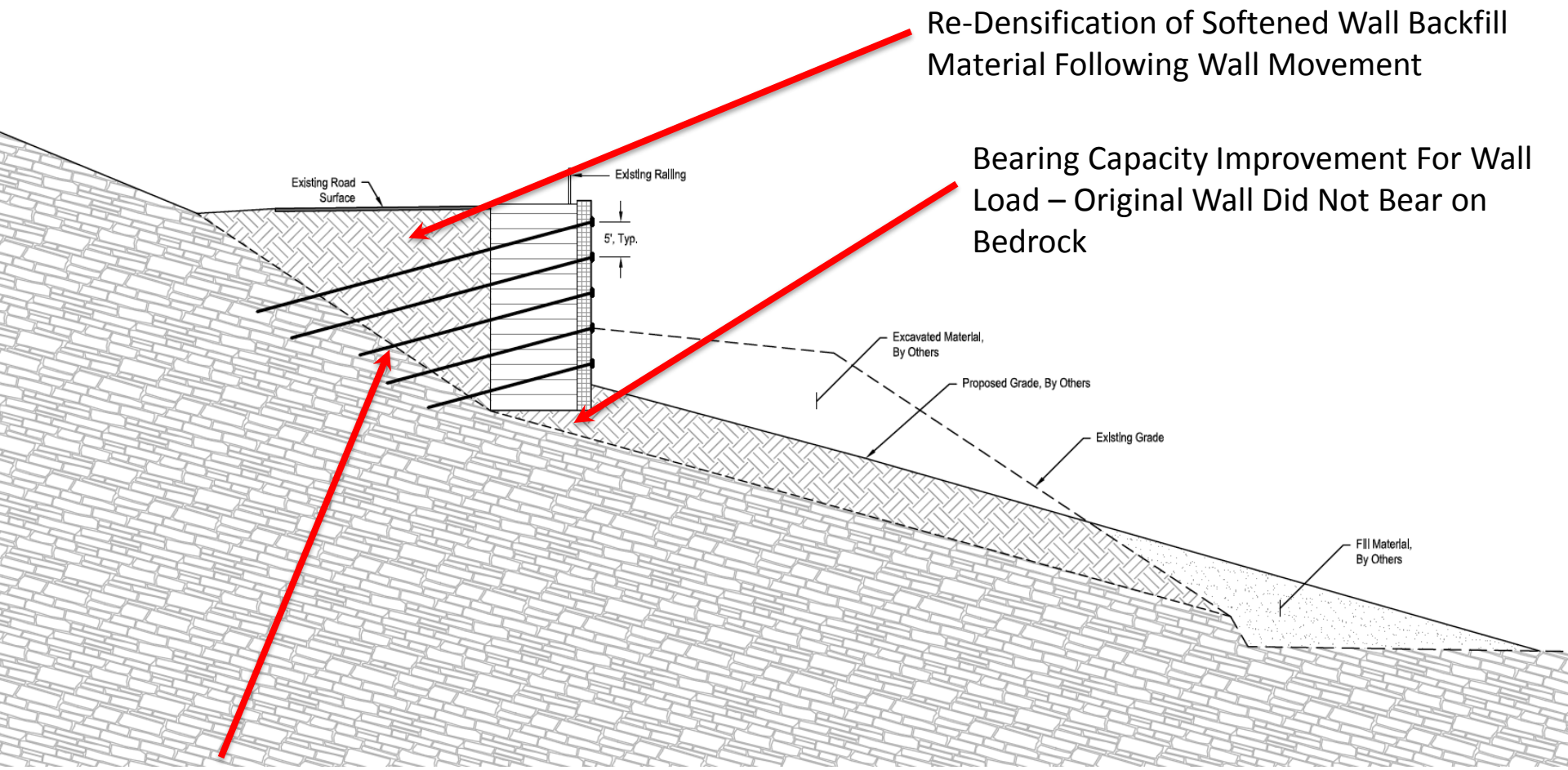
160

38 Road Improvements MSE Wall Repair



MSE Wall Was Stabilized In-Place With Soil Nails

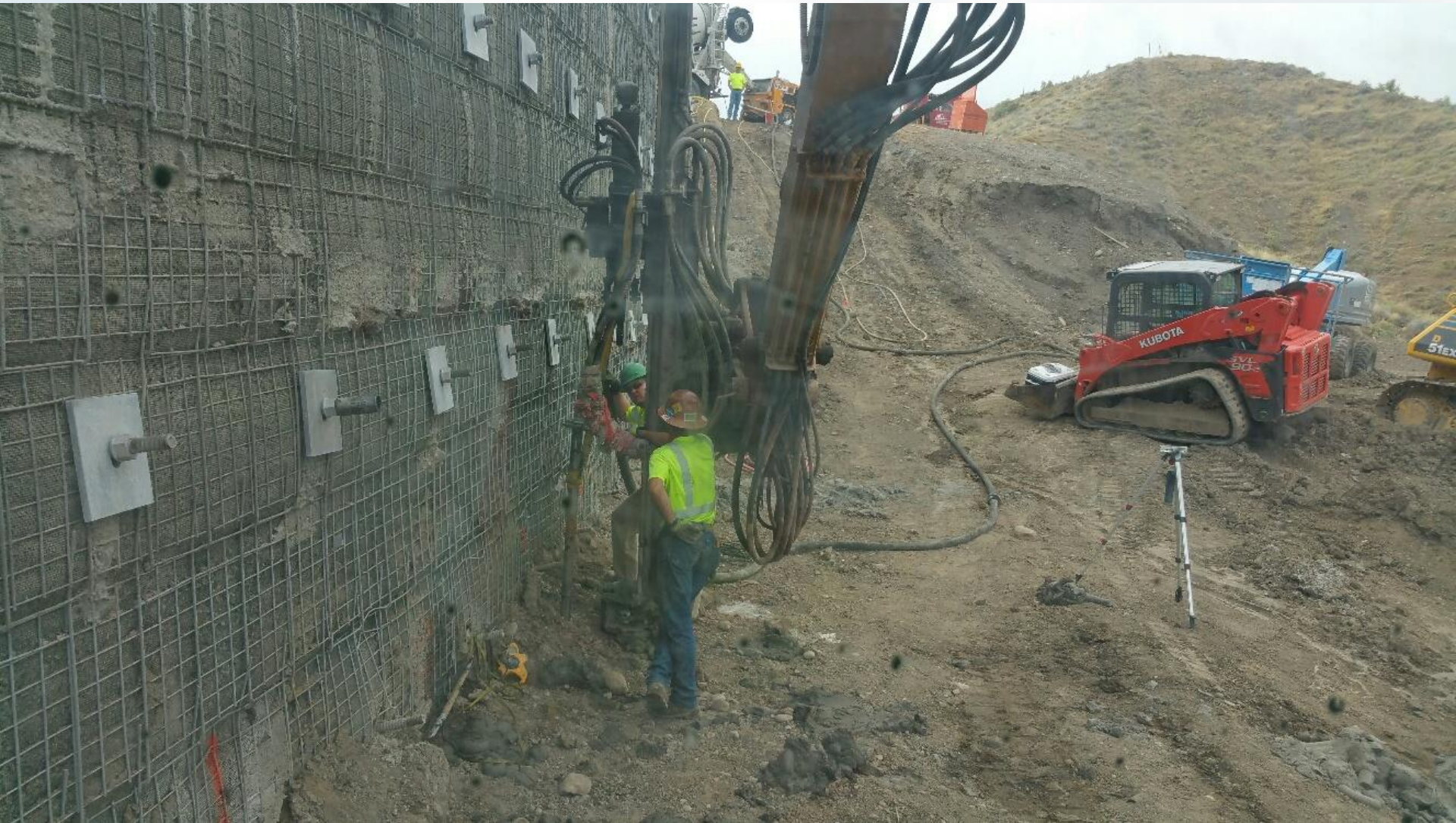
38 Road – Emergency Wall Stabilization

- Purpose of the Grouting
  - At top of wall
    - Once the wall had been stabilized, compaction grouting was used to densify softened and voided zones that were created as a result of the slope/wall movement in order to reduce future settlement potential of the roadway surface in the following years (decreasing future maintenance costs)
  - At base of the wall
    - Compaction grouting was used to increase the bearing capacity of the soil under the wall face and wall backfill within approximately 4 ft of the wall face in order to prevent additional wall settlement and potentially resulting rotationleading to further pavement distress thereby decreasing future maintenance costs

Casing Installation

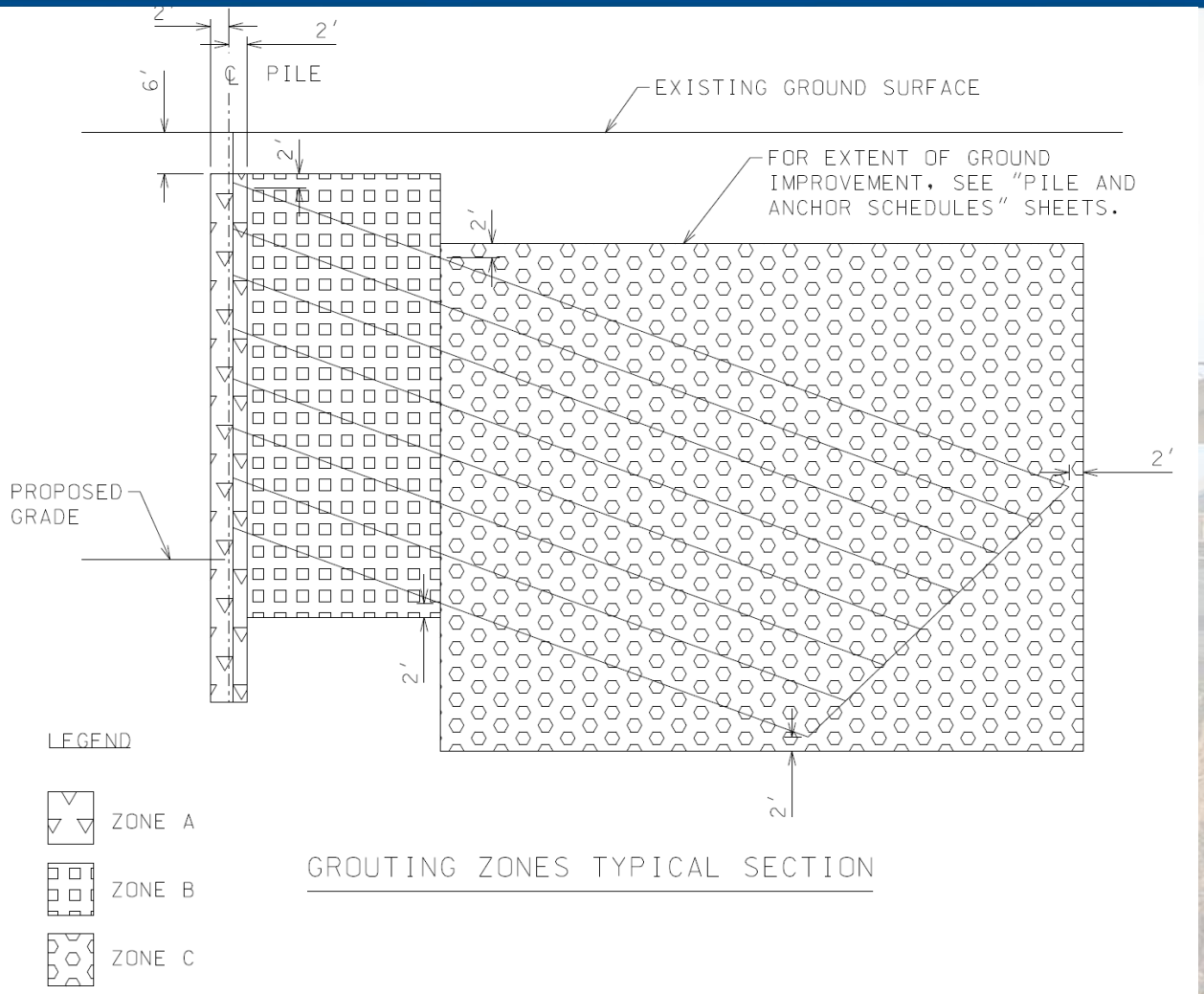
Compaction Grouting – While monitoring injection pressures, quantities, and ground movement

Casing Installation for improvement below existing MSE wall

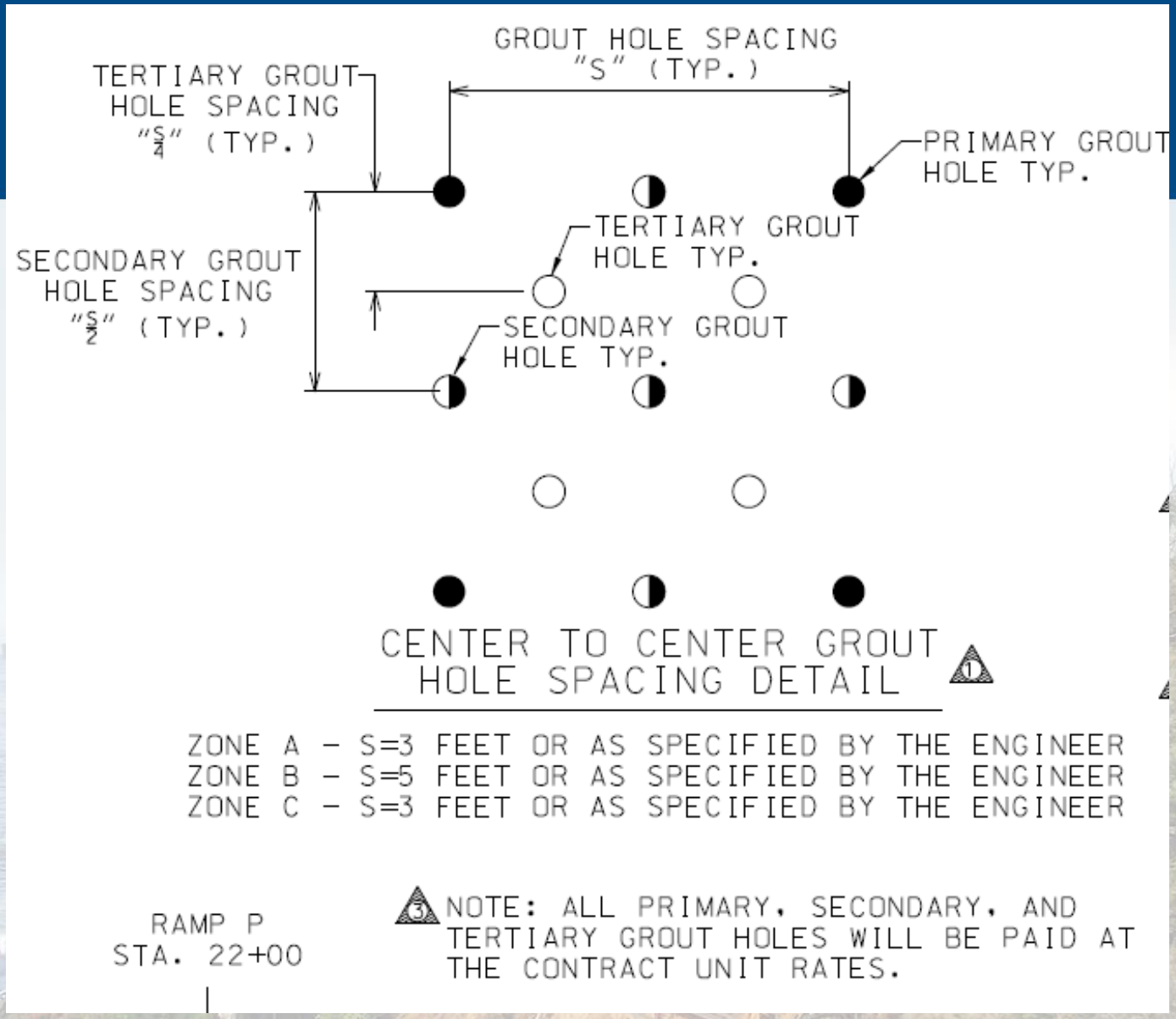


CNP230 TDOT – Random Fill Grouting Behind Planned Anchored Soldier Pile and Lagging Wall

Chattanooga, TN



- Anchored Soldier Pile Wall Up to 60 ft Tall
- Portion of Soil Behind Wall is 50 Year Old Backfill, Debris, Concrete, Steel
- Ground Anchors Must Bond in Fill Due to ROW/Easement Restrictions
- Compaction Grouting Will Improve Fill and Increase Anchor/Soil Bond Values



CENTER TO CENTER GROUT HOLE SPACING DETAIL (1)

ZONE A - S=3 FEET OR AS SPECIFIED BY THE ENGINEER
ZONE B - S=5 FEET OR AS SPECIFIED BY THE ENGINEER
ZONE C - S=3 FEET OR AS SPECIFIED BY THE ENGINEER

RAMP P
STA. 22+00

(3) NOTE: ALL PRIMARY, SECONDARY, AND TERTIARY GROUT HOLES WILL BE PAID AT THE CONTRACT UNIT RATES.

SPT SPECIMENS AS WELL AS STANDARD PENETRATION TEST (SPT) N-VALUE. SUCCESS CRITERIA SHALL BE NO VOIDS LARGER THAN 1/2 INCH VERTICAL EXTENT, NOT LESS THAN 50% RECOVERY OF SPT SAMPLES, AND SPT N-VALUES NOT LESS THAN 11 BLOWS PER FOOT IN COHESIONLESS SOIL OR 5 BLOWS PER FOOT IN COHESIVE SOIL.

THANKS!